Appendix E: Strategic Plan for Managing Nonnative Invasive Species:

A CALFED Bay-Delta Program Strategic Plan for Managing Nonnative Invasive Species in the San Francisco Bay-Delta Estuary/Sacramento-San Joaquin Rivers and Associated Watersheds

July 2000

TABLE OF CONTENTS

Appendix E: Strategic Plan for Managing Nonnative Invasive Species in the San Francisco Bay-Delta Estuary/ Sacramento-San Joaquin Rivers and Associated Watersheds

SUMMARY

The purpose of this Non-native Invasive Species (NIS) Strategic Plan is to provide guidance for management actions to prevent introductions, provide control and mitigate impacts of non-native species that have invaded or may invade the ecosystems of the San Francisco Bay-Delta, the Sacramento/San Joaquin Rivers and their watersheds. This document has been developed for the CALFED Bay-Delta Program. It is an important first step in the coordinated response to this serious problem and communicates the scope of activities necessary to effectively deal with NIS.

The plan discusses the problem and identifies the goals and major issues relevant to feasible, cost-effective management practices and measures to be taken by federal, state, local and other programs to prevent and control NIS infestations in a manner that is environmentally sound. It is important to note that the information developed by NIS activities will be provided to the CALFED Program Managers and the Comprehensive Monitoring, Assessment and Research Program in order to assist these CALFED elements to more effectively achieve CALFED goals and objectives.

The focus of this plan is directed at the San Francisco Bay-Delta estuary, the Sacramento-San Joaquin Rivers and the associated watersheds in California, though it is recognized that the solution area may be statewide and beyond.

This strategic management plan is based on the following three goals:

- Goal I: Preventing new introductions and establishment of NIS into the ecosystems of the San Francisco Bay-Delta, the Sacramento/San Joaquin Rivers and their watersheds.
- Goal II: Limiting the spread or, when possible and appropriate, eliminating populations of NIS through management.
- Goal III: Reducing the harmful ecological, economic, social and public health impacts resulting from infestation of NIS through appropriate management.

The template for much of this document comes from the efforts to develop a State Plan for California. Contributions for that effort came from the California Resources Agency, California Department of Food and Agriculture, US Fish and Wildlife Service, US Department of Agriculture - Agricultural Research Service and US Army Corps of Engineers. Also contributing to this document were staff from the CALFED agencies and participants from academia, non-profit groups, stakeholder groups and individuals with technical experience with NIS. The information contained in the Strategic Plan for the Ecosystem Restoration Program (September 30, 1998) and the draft Ecosystem Restoration Program Plan, Volume I (October 1, 1998), both CALFED Bay-Delta Program documents, provided further information for this plan. Public comments also will be solicited from local governments and regional entities, and public and private organizations that have expertise in the control of NIS. Comments will be considered and revisions made to the plan, as appropriate.

While this plan provides guidance, it does not stand alone as an instrument to deal with the problem. With this coordinated effort, California will have a more efficient approach for implementing California NIS strategies. Besides the CALFED Bay-Delta Program, California entities should find the document useful for designing projects,

preparing proposals, and prioritizing activities related to the NIS issue.

INTRODUCTION

Most often, the suitability of environmental conditions determines a species range. Normal changes in a species range can also occur over great distances as a result of transport mechanisms such as wind and ocean currents and dispersion by migrating species. Some NIS establish new ranges with little effect on their new surroundings. However, some NIS have established themselves, spread unimpeded and caused substantial negative economic and ecological impacts.

Over the past one hundred years, many NIS have been introduced to the San Francisco Bay-Delta. Within the last few decades, the frequency of intra- and international transfer has been greatly accelerated by various human activities. Some scientists fear that the international trend is toward species homogeneity. Some of the species introductions have been intentional, such as ornamental plants, certain agricultural crops and livestock. Others have been inadvertent; introduced through releases from the horticulture trade, pet trade, aquaculture activities, dumping of ballast water, escapees, etc.

NIS affect ecosystems in several ways that are of concern. The extinction of native species can be attributed first to habitat destruction and secondly to introduced species, whose impacts may include habitat alteration, trophic alteration, community spatial alteration, gene pool deterioration, introduction of diseases and parasites, and contaminant dynamics (Kohler and Courtenay).

One of the many underestimated affects of NIS is the potential for contaminants to be consumed, resuspended and incorporated into the food chain by organisms that have been introduced. In the Great Lakes, there are reports that PCBs and cadmium are being cycled from the water column and sedimented to the bottom of the lakes due to the presence of zebra mussels. In a similar fashion, Asian clams are bioaccumulating contaminants at a remarkable level (Cd and Se in particular) in northern San Francisco Bay. Since its arrival, there are much higher levels of Se in the livers of demersal feeders (diving ducks and sturgeon) in Northern San Francisco Bay.

Genetic pollution refers to the process by which NIS threaten natives with alien genes. Though this is not a new phenomenon, comprehensive treatments of invasion ecology in the mid-1980s did not include genetic competition as a threat. Increasing numbers of NIS and their inter-fertility mean that hybridization is a substantial threat to native biotas.

Ecological engineers are species with particularly great habitat effects; they change the physical and chemical environment through various means. This often results in rendering the habitat unsuitable for historic use, often leading to habitat loss for native species. A good example of this is the plant *Spartina alterniflora*, which invades mudflats and converts them into extensive stands of cordgrass. This alteration disturbs sediment dynamics and reduces shorebird feeding and reproduction habitat.

Some species may find themselves adapting to NIS as a matter of necessity. When riparian habitats are taken over by giant reed or aquatic habitats are taken over by water hyacinth or Egeria, the animals that use these environments to reproduce, feed or escape predation must develop the means to utilize the diminished habitats to survive. This can complicate strategies to remove or otherwise manage non-native invasive plant species, especially if listed wildlife species are observed using the undesirable vegetation.

Strategies to remove or control NIS must consider possible conflicts of this nature to avoid causing unnecessary, significant harm to special status species or other species of concern.

THE PROGRAM

This Strategic Plan has been made possible through the funding of CALFED and the support of CALFED agency, academic, non-profit and stakeholder participants. As CALFED has developed the goals and objectives of their program, they have come to recognize that NIS is a significant stressor of the Bay-Delta. The result has been the initiation of a CALFED NIS Program charged with the responsibility to develop a long-term Strategic Plan, an Implementation Plan, directed projects, an open solicitation for proposals, and coordination of the resulting projects. The U. S. Fish and Wildlife Service has agreed to develop and coordinate this program, in cooperation with CALFED programs and

members. The initial funding is $1.25 million, which will be allocated over FY99 and FY 00. It is anticipated that at least $1,050,000 will be available for on-the-ground work over this two year period and that CALFED funding will become available in future years to continue with implementation actions as identified in the Plans.

In May 1995, the CALFED Bay-Delta Program was established to Arestore the ecological health and improve water management for beneficial uses in the Bay-Delta system. To accomplish this, a draft Ecosystem Restoration Program Plan has been developed to increase aquatic and terrestrial habitats, improve ecosystem functions and reduce the effects of stressors, which includes non-native invasive species.

Management actions of this Strategic Plan will be consistent with the objectives identified in the **STRATEGIC PLAN FOR ECOSYSTEM RESTORATION PROGRAM** (ERP) dated September 30, 1998. Goal 5 of the ERP plan is "Prevent establishment of additional non-native invasive species and reduce the negative biological and economic impacts of established non-native species."

The ERP objectives identified for this goal are to:

Objective 1: Eliminate further introductions of new species in ballast water of ships.

Objective 2: Eliminate the use of imported marine baits.

Objective 3: Halt the introduction of freshwater bait organisms into the waters of Central California.

Objective 4: Halt the deliberate introduction and spread of potentially harmful species of fish and other aquatic organisms in the Bay-Delta and the Central Valley.

Objective 5: Halt the release of fish and other organisms from aquaculture operations into Central California waters, especially those imported from other regions.

Objective 6: Halt the introduction of invasive aquatic and terrestrial plants into Central California.

Objective 7: Halt the release and spread of aquatic organisms from the aquarium and pet trades into the waters of Central California.

Objective 8: Reduce the impacts of exotic mammals on native birds and mammals.

Objective 9: Develop focused control efforts on those introduced species for which control is most feasible and of greatest benefit.

Objective 10: Prevent the invasion of the zebra mussel into California.

The NIS program will work to develop close linkages with the CALFED Program Elements and CMARP. These linkages will enable those programs to take advantage of the information generated by the NIS program activities and facilitate recognition of the special issues and concerns that NIS present to the estuary in general and to specific Program Elements. This insight will allow development of a better understanding of effective ways to address NIS as the work to accomplish the CALFED goals and objectives proceeds.

The purpose of this strategic plan is to provide a planned approach for management actions to address prevention, eradication, control and impacts of NIS that have invaded or may invade the ecosystems of the San Francisco Bay-Delta estuary, the Sacramento/San Joaquin Rivers and their watersheds. This plan should serve as a basic model for resource managers responsible for implementing programs to protect and enhance ecosystems in California.

THE MISSION

The mission of the CALFED Nonnative Invasive Species Program:

PREVENT ESTABLISHMENT OF ADDITIONAL NON-NATIVE SPECIES AND REDUCE THE NEGATIVE ECOLOGICAL AND ECONOMIC IMPACTS OF ESTABLISHED NON-NATIVE SPECIES.

The mission is consistent with Goal #5 of the ERP Strategic Plan.

THE GOALS

Following are the three goals of the CALFED NIS Program with a brief explanation of the problem and some insight into the issues, current activities and necessary actions.

GOAL I: PREVENT NEW INTRODUCTIONS OF NIS INTO THE ECOSYSTEMS OF THE SAN FRANCISCO BAY-DELTA, THE SACRAMENTO/SAN JOAQUIN RIVERS AND THEIR WATERSHEDS.

PROBLEM: The introduction of NIS into California, including inland state waters, frequently causes environmental, socioeconomic, and public health impacts. The severity of these impacts is not widely known or recognized which impedes the investment of resources needed to prevent new NIS introductions. Also, a delayed "crisis-response" approach often limits the vision and opportunity for the prevention of new introductions, leaving California with NIS management problems that are economically costly, technically challenging, if not infeasible to solve, and frequently irreversible. Although numerous NIS already have been introduced into California ecosystems, new introductions continue to occur. The prevention of new introductions is critical in the amelioration of NIS problems in California.

California has a long and successful history of preventing the introduction of exotic invasive pests that threatened California agricultural and natural resources. The strategy of CDFA's Pest Prevention System is consistent with the strategies of the Aquatic Nuisance Species Plans currently developed by other states (Washington, Ohio, New York, etc.) and regions (Colorado River Basin). A major component of CDFA's Pest Prevention systems is the Pest Exclusion Program which includes a statewide network of border station and port inspection activities. Although these areas of inspection concentrate on agricultural pests, they have intercepted non-native aquatic species. For example, California border station employees have intercepted 18 vessels, from eastern and mid-western states, that contained zebra mussels. Three of these vessels contained live zebra mussels. A fourth vessel was so heavily infested that live specimens were probably present and treatment was recommended prior to allowing the vessel into California waters.

Detection of zebra mussels and other NIS at the border stations has potentially saved hundreds of millions of dollars in economic losses associated with impacts to water conveyance systems, hydroelectric power plants and loss or alteration of natural aquatic habitats. California will benefit by expanding CDFA's Exclusion Program to include NIS. The US Department of Agriculture and US Department of Interior should enter into partnership with CDFA and the California Resource Agency to identify ways to expand CDFA's Exclusion Program and obtain the needed funding to accomplish this task. The CALFED Program could play a vital role in facilitating this effort.

Multiple mechanisms transport NIS into California's waters and some mechanisms transcend the authority of a single state to control. A prime example is ballast water discharge from transoceanic shipping, the largest source of nonindigenous aquatic species invasions worldwide {Carlton 1985}. Cooperative efforts are necessary between state, federal (i.e., Coast Guard and USDA), and international agencies to promulgate and enforce regulations to ensure that ballast management practices and other related transport mechanisms are employed to prevent NIS introductions. There is much attention currently directed at the efforts in the San Francisco Bay to encourage responsible ballast water management practices through the use of existing regulations. There is more extensive discussion of these activities in the Policy Background section.

Current technology is frequently inadequate to prevent new introductions of NIS into California ecosystems. Research on prevention strategies to minimize NIS transport, such as innovative ballast water management technology, is critical in the effective prevention of NIS introductions. Ongoing studies by the U.S. and Canadian Coast Guards indicate that it is especially important to deal with the difficult problem posed by vessels entering the coastal and major navigable waters with residual unpumpable ballast water and sediment in their tanks. This medium, potentially harboring a variety of NIS, is often mixed with California's fresh water and discharged at another California location or port. In order to achieve more effective emptying or flushing of these tanks, the feasibility of altering the

current design of ballast tanks needs to be examined. Other significant transport mechanisms increasing the potential for new introduction of NIS into California include the aquaculture business, commercial barge traffic, recreational boating, the bait industry, the pet shop trade, plant nurseries, and fish stocking activities- all of which have the potential to introduce NIS as well as associated parasites and other disease organisms. The pet shop and aquatic plant nurseries trade are quite problematic, offering increasing numbers of easily introduced aquatics like Hydrilla. In some cases, such activities are subject to little or no regulation. In cases where laws and regulations do exist, they are frequently not well publicized or enforced. There are often gaps in the current laws. There is further explanation of the existing laws in the Policy section. An extensive effort must be made to reach out to user groups that could potentially introduce NIS into California and are generally not adequately informed of NIS prevention practices.

GOAL II: LIMIT THE SPREAD OR, WHEN POSSIBLE AND APPROPRIATE, ELIMINATING POPULATIONS OF NIS THROUGH MANAGEMENT.

PROBLEM: The spread of established populations of NIS into uninfested areas is often via human activity, such as boat transfers, ballast exchange, bait handling, water transport, intentional introduction by anglers, and ornamental and landscape practices. Limiting the spread of such populations is problematic due to the numerous pathways of dispersal, the complex ecological characteristics associated with NIS populations, and the lack of technology that is needed to limit the spread.

Many public and private resource user groups are not aware of existing infestations of NIS in San Francisco Bay, Sacramento-San Joaquin Estuary, or the inland waters of California, and why they cause problems. The probability of NIS spread to other waters can increase when resource user groups are not aware of the consequences of illegal introductions of NIS, or how their routine activities can cause the dispersal of NIS into uninfested areas. An information and education program is needed to provide information on why the spread of NIS populations needs to be limited, how the NIS populations can be reduced, and also the value of healthy ecosystems that support a diverse native community. Information and education is also critical to strengthening public and private support for statewide participation in NIS management strategies.

It is also difficult to manage the spread of NIS since infestation frequently occurs in watersheds that occupy more than one county. Cooperation among all counties in California sharing NIS infested watersheds is needed to implement consistent management strategies that will effectively limit the spread of NIS populations.

GOAL III: REDUCE THE HARMFUL ECOLOGICAL, ECONOMICAL, SOCIAL AND PUBLIC HEALTH IMPACTS RESULTING FROM INFESTATION OF NIS THROUGH APPROPRIATE MANAGEMENT.

PROBLEM: The NIS infestations in California can have ecological, economic, social and public health impacts. Strategies to control NIS and efforts to abate their impacts are not always known or technically and/or economically feasible. It should be recognized that these efforts are no substitute for prevention, which should always be the highest priority.

The NIS infestations in California's aquatic ecosystems can alter or disrupt existing ecological processes. Without co-evolved parasites and predators, some NIS out-compete and even displace native plant or animal populations. As part of this process, the invading species can also influence the foodwebs, nutrient dynamics, and biodiversity of the ecosystems. To abate the ecological impacts of the invading organism, it is necessary to understand the mechanisms by which the species disrupts the natural balance of the ecosystem.

Some introduced NIS to California have provided economic benefits, such as those supporting the aquaculture business and sportfishing industry. However, several NIS have been found to cause adverse economic impacts. Organisms invading California's waters can threaten public health through the introduction of disease, concentration of pollutants, contamination of drinking water, and other harmful human health effects. An extensive abatement system for these NIS needs to be established to prevent human health problems from occurring in California.

It is often difficult to assess the ecological, socio-economic and public health impacts of NIS in terms

that are meaningful to decision makers and the general public. Actions to abate NIS impacts through control strategies are frequently impeded by circumstances, such as the absence of political support and the lack of resources needed to effectively develop and implement control strategies.

The strategic approach to this plan recognizes prevention as the most practical, economic and environmentally safe method for dealing with new or incipient infestations. An effective prevention program must include an exclusion component to prevent introductions into California, a detection component to identify incipient infestations and an integrated pest management component to eradicate or control species with minimal or transitory impact to the habitat and nontarget species. All three components need to have strong research, public information and awareness support to be effective, timely and responsive. For NIS already widely established and distributed, this plan emphasizes an ecosystem approach to management, (as opposed to a species by species approach) utilizing integrated pest management methods that are flexible and environmentally sound.

NIS IN THE BAY-DELTA

In the last one hundred years, there have been over 212 introductions of species into the Sacramento-San Joaquin Estuary. Many of these species are believed to have traveled here via ballast water of ships. The incidence grows with the increase in trade between Pacific Rim nations because many species are carried in the ballast water of ocean-crossing vessels. Since 1970, many new species of zooplankton, clams, amphipods, crabs and fish have become established in the Sacramento-San Joaquin Estuary (Cohen and Carlton, 1995).

Aquatic ecosystems such as the Sacramento-San Joaquin Delta are comprised of many interrelated organisms which include phytoplankton (algae), macrophytes (vascular plants), invertebrates, fish, birds and mammal. These organisms require a certain set of chemical and physical conditions to exist, such as oxygen, light, nutrients adequate movement of water and adequate space.

Scientists and other NIS experts have recognized the fact that healthy ecosystems are impacted by the establishment and spread of exotic species. A habitat that is disturbed seems to be at even higher risk for establishment and negative impacts due to introduced species. The CALFED program includes an aggressive and expensive effort to increase shallow water habitats in the Delta, as well as restore the health of those already in existence. Failure to identify and develop a comprehensive strategic approach to the problem associated with invasive aquatic species could negate or undermine benefits gained from these efforts (increasing flows, reclaiming agricultural lands and eliminating or redistributing levees) to improve and expand habitat for native, beneficial, and endangered aquatic species.

In the last hundred years, human mobility has greatly accelerated and with this movement plants and animals have been introduced, either deliberately or accidentally into new environments with unforeseen consequences. Starlings, the boll weevil, rats in Hawaii, the zebra mussel and sea lamprey in the Great Lakes, and water hyacinth in California's Sacramento-San Joaquin Delta are some of the infamous cases of species becoming pests when introduced into new environments. The Nature Conservancy in a recent report entitled "America's Least Wanted" details how approximately 4000 exotic plant and 2300 exotic animal species have threatened native species and how some of these exotics have ended up costing the economy an estimated $97 billion.

AQUATIC PLANTS

Submersed, emersed, and floating aquatic plants are natural and important components of aquatic ecosystems. In a well balanced aquatic ecosystem, aquatic plants provide protective cover for fish as well as habitat and a source of food for organisms consumed by fish. Aquatic plants also provide nesting sites and food for birds and other animals. In addition, aquatic plants can increase water clarity and quality and improve the appearance of a water body.

The spread of nonnative flowering aquatic plants has increased dramatically over the past 25 years in California and has created many economic and ecological impacts. Demands on the state's water resources, which include irrigation water delivery, recreational and domestic (drinking) uses, and fisheries and waterfowl habitats, have exacerbated these impacts. The introductions of NIS have

consistently upset the delicate ecological balance of many aquatic systems. Furthermore, large-scale infestations of aquatic NIS have proven to be a severe impediment to boating, fishing, swimming, water delivery, and generation of hydroelectric power. The hallmark of aquatic invaders is their ability to grow in low light levels and their rapid, prolific, and varied reproductive abilities.

According to the California Department of Food and Agriculture, the aquatic plant species causing most of the problems in California are: *Eichhornia crassipes* (water hyacinth), *Egeria densa* (Egeria), and *Myriophyllum spicatum* (Eurasian water milfoil). There is also an intensive *Hydrilla verticullata* (Hydrilla) control program underway to limit the spread and reduce the impacts from this aquatic plant. This program intends to contain this pest and prevent it from causing widespread problems.

Water hyacinth has been under management for 15 years, and a bill authorizing the management of Egeria passed the state legislature in 1996. The combined costs of these efforts to control fewer than 25% of the infestations will probably equal or exceed the $1 million annual Hydrilla eradication expenditures. Management of water hyacinth and Egeria by using biological control agents may be the long-term goal, yet safe and effective herbicides and mechanical control strategies need to be used in the interim to prevent further spread of these weeds.

WETLAND PLANTS

Several invasive plant species on the California Exotic Pest Plant Council's (CALEPPC) list of plants of greatest ecological concern threaten the wetland habitats of the Bay-Delta system. Cordgrass introduced from the Atlantic coast has spread very rapidly in Pacific estuaries in northern California, Oregon, Washington, and British Columbia and now invades the San Francisco Estuary. The introduction of smooth cordgrass (*Spartina alterniflora)* has led to dense coverage of about 30% of the intertidal area in Willapa Bay, Washington. The introduction to San Francisco Bay has resulted in rapid colonization of the south end of the bay. It is now known to hybridize with *Spartina foliosa*, the native cordgrass, which confounds the problem of identification and eradication.

Spartina alternaflora and *S. densiflora* are the introduced cordgrass species of greatest concern (Grossinger and Cohen,1998). *Spartina patens* and *S. anglica* are of secondary concern according to this report based on input from regional wetland scientists and managers.

Smooth cordgrass is a substantial threat to wildlife, fisheries, and traditional uses of Pacific estuaries. Replacing the naturally open mud of Pacific estuaries with monospecific grass prairie, the dense canopy and tightly interlocked rootmats of these weeds exclude shorebirds, native vegetation, fish, and many invertebrates. Scientists that study and document these impacts, sometimes refer to NIS which invade in this manner, altering the physical characteristics of the habitat, as ecological engineers.

Other wetland invasive species include those found in upland-wetland transitions, but are now invading high-marsh terraces. Pepperweed (*Lepidium latifolium*) is a particularly aggressive invader and is proving difficult to eradicate. Its rhizomes can be resistant to herbicide applications and it is fairly euryhaline. *Salsola soda,* a member of the Chenopodiaceae family, is another plant that threatens native pickleweed marshes. In a recent survey Tamasi (1998) reports *S. soda* in the Bay-Delta system from Calhoun Cut near Hastings Tract down to the southern end of the South Bay. Grossinger and Cohen (1998) cite both of these species as needing attention.

RIPARIAN PLANTS

Recent introduction and spread of purple loosestrife *(Lythrum salicaria)* threaten the state's riparian systems. It has recently been observed invading some Delta levees (e.g. White Slough). According to CALEPPC's 1996 list of exotic pest plants of greatest concern, purple loosestrife status is red alert. Giant reed (*Arundo donax*) is another species that is receiving considerable attention both nationally and in California. There are now five regional teams dedicated to control and eradication of giant reed in the state. This plant is known to aggressively displace native riparian vegetation and is so disruptive that it affects water quality and quantity, exacerbates flooding, and alters the geomorphology of the waterway it invades. Giant reed is widespread throughout the CALFED problem and solution areas.

Other plants that threaten our riparian or wetland systems include blue gum eucalyptus (*Eucalyptus globulus*), salt cedar (*Tamarix* spp.), Russian olive (*Eleagnus angustifolia*), Himalayaberry (*Rubus discolor*), Cape ivy (*Delairea odorata*; formerly known as German ivy, *Senecio mikanioides*), hoary cress (*Cardaria draba*), tree of heaven (*Ailanthus altissima*), thistles (*Cirsium arvense* and *C. vulgare*), and periwinkle (*Vinca major*).

The above species are only a few of the approximately 80 species listed as Aproblem exotic plants reported in California wetlands from a survey of resource managers representing six bioregions of the state (Dudley,1998). Clearly, much work remains to be done in identifying the threats to wetland and riparian habitats posed by these invasions, prioritizing research and eradication, and monitoring progress.

CLAMS AND ZOOPLANKTON

One species having a major impact is the small Asian clam, *Potamocorbula amurensis*. After it first appeared in 1986, the clam rapidly colonized the brackish water portion of the estuary throughout San Francisco Bay to the western edge of the Delta. It was the dominant bivalve south of San Mateo Bridge by 1991. The clam has affected the base of the food web by removing much of the algae, which is food for zooplankton. This clam is so abundant that calculations indicate that the population can filter a volume of water equal to the entire water column in 24 hours. It has apparently greatly reduced abundance of the native copepod *Eurytemora affinis*, a dominant zooplankton species providing food for many larval fish. Ironically, some recently accidentally introduced zooplankton species now provide food for young fish and may help fill the void caused by the decline in *Eurytemora affinis*. The mysid *Acanthomysis bowmani* was first reported here in 1993 and has increased in abundance, while the native mysid *Neomysis mercedis*, another important food item for young fish may have been greatly reduced in abundance through competition for food with the Asian clam.

CRABS

Two exotic crabs, the Chinese mitten crab *Eriocheir sinensis* from Asia and the green crab *Carcinus maenas* native to Europe, have also become established in the Estuary. The mitten crab, first found in South San Francisco Bay in 1992, was collected in the Delta in the fall of 1996 and since then has traveled upstream in the Sacramento River north of Colusa and upstream in the San Joaquin to Gustine. The mitten crab may have been deliberately and illegally introduced or it may have been introduced via ballast water. It is known to damage rice crops in China, and it is a potential competitor of crayfish, which supports a commercial fishery and is an important forage species for fish in the Delta. The mitten crab potentially could burrow into and weaken the levee system in the Delta if it becomes more abundant. The green crab is non-burrowing but inhabits the intertidal zone in San Francisco Bay, San Pablo Bay and has been found in Suisun Bay where it may compete with shorebirds and other crabs for food. The green crab is a voracious predator of shellfish and native shore crabs, and it is believed that it could fundamentally alter Bay-Delta invertebrate species distributions, and imperil aquaculture such as oyster farming. It has apparently spread rapidly from San Francisco Bay, where it was first captured in 1989 or 1990 (Cohen and Carlton, 1995), up the coast of California to Willapa Bay and Grays Harbor, Washington.

FISH

It is well known that a number of introduced fish have become established in this estuary over the past one hundred years. They include striped bass, catfish and several members of Centrarchidae. Some of these fish now support popular fisheries and are considered by many to be a valued recreational feature of the watershed. Outside of the Sacramento-San Joaquin Delta, unauthorized planting of the Inland silverside, *Menidia beryllina*, into Clear Lake occurred in 1967, and it was likely dispersed into the Delta from Clear Lake by high winter flows. The fish was established in the estuary by 1975. It is suspected to prey upon larvae of other fish and may compete for food with the delta smelt, *Hypomesus transpacificus*, a threatened species. The delta smelt is also faced with the threat of hybridization and competition with a morphologically similar smelt species, the wakasagi, *Hypomesus nipponensis*. A growing problem in California is ill-advised anglers who desire and introduce exotic species. Intentional illegal introductions can have great economic consequences. The white bass, *Morone americana*, a species native

to the Midwest, was eradicated from Kaweah Reservoir in Tulare County with rotenone in 1987. Northern pike, *Esox lucius*, another species native to the Midwest, was illegally stocked into Frenchman Reservoir, Plumas County, in the 1980s. In March 1991, the Department of Fish and Game treated Frenchman Reservoir and successfully eradicated northern pike. A similar program was conducted in 1997 to eradicate northern pike from Lake Davis in Plumas County. Biologists were concerned that if these two predatory fish species became established throughout the watershed, they would decimate populations of salmon, trout and other fish, including some that are threatened or endangered. These eradication efforts cost over one million dollars each. These expenditures are necessitated by the irresponsible behavior of a few individuals who either do not understand or do not care about the environmental and economic consequences of their illegal actions.

NONNATIVE WILDLIFE

Nonnative wildlife is present throughout the Sacramento-San Joaquin Valleys in a variety of habitats. These include aquatic, riparian scrub, woodland and forest habitats; valley oak woodland; grassland and agricultural land. Non-native wildlife species negatively impact native organisms mainly through predation or competition. These nonnatives often have a competitive advantage because of their location in hospitable environments where the normal controls of disease and natural enemies are missing. The result is diminished abundance of native species. Some of the common but harmful species found in the Bay-Delta area are:

- The European red fox, which threatens many native endangered wildlife species, such as the clapper rail and several other San Joaquin Valley animals.
- The Norway rat, which threatens ground-nesting wildlife, has experienced large increases in the populations living along the bay shores.
- The feral cat which is a major predator to bird and mammal populations in the wetland areas of the Bay-Delta estuary.

IMPLEMENTATION ISSUES

The development of this Plan has led to the conclusion that there is one element that is necessary to the success of any program which addresses the prevention, management and eradication of NIS. That essential element is a group of individuals that come together to form an advisory council to monitor and coordinate the efforts of the program. For this Plan, the formation of this group is identified as a Programmatic Action below.

PROGRAMMATIC ACTION

PROGRAMMATIC ACTION: FORMATION OF AN INTERAGENCY NON-NATIVE INVASIVE SPECIES ADVISORY COUNCIL (NISAC) TO MONITOR MANAGEMENT EFFORTS AND ASSURE EFFECTIVE COORDINATION OF THIS PROGRAM WITH CALFED AND OTHER NIS PROGRAMS.

California natural and man made water conveyance and impoundment systems are available and utilized for multiple purposes. In addition, there is a complex mosaic of federal, state and local laws and regulations which not only address intended use of these resources but will impact efforts to prevent the introduction, establishment and management of NIS. To facilitate accomplishment of the strategic goals, this program must coordinate with jurisdictions within and outside the state and build tasks and actions upon sound science. Therefore, mechanisms will be established to ensure that all prevention, control and abatement tasks and actions developed and implemented by this program under this plan are (1) done in cooperation with federal agencies, local governments, interjurisdictional organizations and other entities, as appropriate (2) based upon the best scientific information available, (3) conducted in an environmentally-sound and conscientious manner and (4) coordinated through NISAC.

As presented in the Implementation Section on page 7, there are also a number of major issues critical to achieving the goals as presented in this plan. These issues are discussed below and will be addressed as objectives of the Implementation Plan with specific Tasks and Actions.

LEADERSHIP, AUTHORITY AND ORGANIZATION

As the program develops, one of the components essential to actual implementation will be to identify the leadership, authority and organization that are necessary to accomplish each goal. In some cases, there will be existing organizations that have the leadership and authority to carry out the actions identified in the plan. The CALFED NIS Program will develop relationships and support the efforts of these organizations. It may be that other tasks and actions determined to be essential to the success of the program do not have the leadership, authority or organization in place. In these instances, we will work to identify and/or develop the appropriate component needed to carry out the work as a part of the CALFED NIS Program.

COORDINATION, COOPERATION AND PARTNERSHIP

For all of the work undertaken as part of this program, the value and necessity of the elements of coordination, cooperation and partnership to the success of the program can not be overstated. At all times and in all aspects of the work, priority will be given to these ideals and we will strive to incorporate them into every aspect of plans made and actions taken. There are many entities and organizations developing or operating programs to address NIS, including local, regional, state and national. The programs and organizations that deal with the issues and organisms that are of concern to the CALFED objectives will be identified and cooperative relationships will be developed with these entities. Emphasis will be given to projects where partnerships can be developed to improve efficiency, support and effectiveness of activities. There is further discussion of this issue in the Policy Background section.

EDUCATION AND OUTREACH

A comprehensive awareness and education program is critical for an effective NIS management program. Except for isolated cases that have attracted substantial media attention, the general public does not understand how NIS negatively impact the environment, the economy and the use of the natural aquatic resources that are important to them. Therefore, a strategic approach to NIS must include an education and awareness component for all actions and tasks presented. Developing and implementing a coordinated and comprehensive information program will expand understanding by all California citizens of the impacts and risks associated with the introduction and spread of NIS.

Information about the nature, characteristics, and the impacts of NIS on the environment, economy, and quality of life needs to be made more available. This information should be presented concurrently with information about related issues such as threatened and endangered species, water quality, habitat restoration, and ecosystem health. An important aspect of this program will be developing outreach to inform and educate not only the public, but also private entities that may be contributing to the problems and/or may be affected by project actions. The need for understanding and managing NIS should be institutionalized in public and environmental education curricula. A well-coordinated effort is needed because of the costs and complexities associated with developing and delivering a comprehensive, high caliber outreach program.

A successful education and information program must utilize individuals and institutions with expertise on raising public awareness and influencing attitudes towards NIS management. Public information specialists can be utilized to develop, distribute and coordinate information statewide. In addition, information specialists can enhance public interest and improve citizen and organizational involvement to reduce the spread of NIS. Raising awareness can be achieved via television spots, ad campaigns, outreach to schools, and public service announcements.

An increased awareness and concern of California citizens should precipitate an increased level of commitment by elected officials toward NIS management. Many federal and state legislators have little understanding of the risks associated with NIS and this has had a negative impact on obtaining sufficient long-term funding. An immediate priority should be the development of briefing packages and presentations for national, state, and local officials and interest groups.

FUNDING AND RESOURCES

In California, the funding for management of NIS is not reliable or consistent and in many cases is inadequate or nonexistent. This is especially true in the areas of exclusion, education, emergency response, research and management. Funds are generally available on a reactive basis and do not effectively deal with infestations before they become unmanageable. Except for the Hydrilla Program conducted by California Department of Food and Agriculture, or the Northern Pike Program conducted by California Department of Fish and Game, funds for NIS are usually provided only after the problems become widespread, provide resources for only limited control efforts and do very little to prevent further spread to uninfested areas.

Costs associated with this management plan and associated implementation plans must be identified. The CALFED Program has provided initial funding for development of the NIS Program and to begin high priority projects. It is the intent of the CALFED Program that as future funding becomes available, the CALFED NIS Program will continue to receive support to carry out the NIS projects that will contribute to the success of the CALFED Program objectives. Also, traditional sources of financial support which will be pursued include the US Fish and Wildlife Service, ANS Task Force, US Army Corps of Engineers, US Environmental Protection Agency, Natural Resource Conservation Service and the National Fish and Wildlife Foundation. For federal agencies, allocations of discretionary funds will likely be inadequate. It is necessary to acquire dedicated funding to assure the continuity and viability of this Program. At the state level, one or more agencies may have to submit Budget Change Proposals to obtain long-term funding in support of a statewide management program. It should be recognized that discretionary funding would not be adequate to address the full scope of this problem. Funding needs are substantive and appropriations will be necessary to carry out this Plan.

In addition to traditional funding sources, a working group within the NISAC, should develop a number of nontraditional funding options for NISAC consideration and recommendation. These funding options should recognize that management of NIS benefits all Californians and will actually prove cost-effective over the long term.

Other nontraditional sources of revenue and resources involve cooperative agreements and partnerships. Federal, state, local agencies and private organizations with NIS management responsibilities should be encouraged to coordinate, share, or pool resources. This can include shared purchase of supplies and use of equipment, savings for bulk purchases of chemical supplies, use of staff and other human resources, sharing of mapping and monitoring data and expertise, biological control and educational materials.

MONITORING, MAPPING AND ASSESSMENT

As part of the CALFED program, a Comprehensive Assessment, Monitoring and Research Program (CMARP) is under development to address the needs of CALFED's common programs and related agency programs regarding monitoring, research and assessment. The CALFED NIS Program will communicate and coordinate with all pertinent CMARP programs and activities.

Ecosystems infested with NIS are not consistently identified and delineated. Complete up- to-date maps, displaying the distribution and severity of NIS infestation are available in only a few areas. Knowledge of which species are located where is paramount for: 1) increasing public awareness and concern, 2) obtaining support and funding for developing a strategic program, 3) accurately predicting where new infestation may occur from already infested areas and, 4) developing effective integrated management and prevention plans with specific actions to mitigate or prevent NIS impacts.

Risk assessment involves identifying geographic areas that may be at risk for successful establishment of particular species. This type of assessment can be an essential element of a successful prevention program by identifying areas of specific concern and affording the opportunity to direct resources in the most beneficial and efficient manner.

A georeferenced ecosystem inventory, mapping and monitoring system will be based on standards which allow for easy exchange of information among federal,